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Fire Helps the Lonesome Pine

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RESEARCH SUPPORTING SOUND DECISIONS

Six years after a prescribed fire, a north Georgia site shows successful regeneration of both hardwoods and Table Mountain pine.

Fire Helps the Lonesome Pine

Summary

Regeneration of Table Mountain pines in the Southern Appalachian has been on the decline since the 1950s. From central Pennsylvania to northeast Georgia, stands of these pines are beginning to be dominated by oaks, particularly chestnut oak, and by hickories. It has been believed that this is because the shade-intolerant pines are being replaced by more shade tolerant hardwoods and shrubs, largely a result of fire exclusion in these areas. Few studies have evaluated fire as a tool for replacement of this species. Some prescriptions have called for intense crown fires, but these narrow the burning window and cause concerns about worker safety and smoke management.

Further, some studies have shown that some high-intensity fires have had poor pine regeneration, possibly because of excessive drying of the seedbed habitat or complete destruction of the cones on standing trees. A recent research project suggests that periodic lower intensity fires may cause more hardwood mortality than initially believed, and these may actually be better tools for Table Mountain pine replacement.

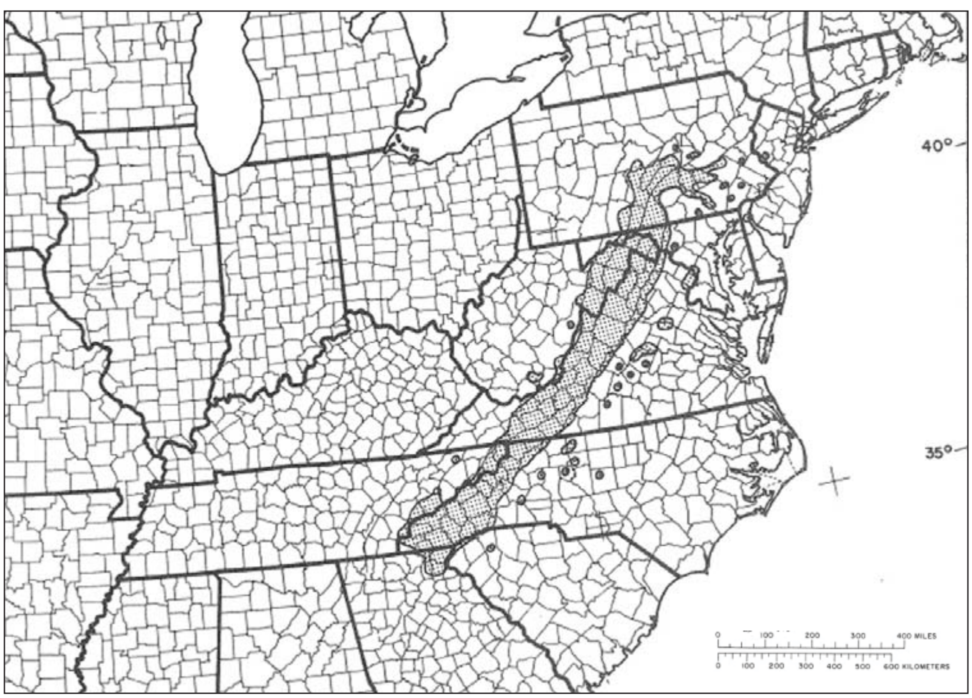
Key Findings

- Over 50 years of fire suppression in the Southern Appalachian Mountains has prevented regeneration of Table Mountain pine stands.
- Higher-intensity fires result in more complete elimination of overstory hardwood competition for the pines and more rapid regrowth of both pines and competing hardwoods and shrub species.
- Lower-intensity fires do eventually reduce the hardwood overstory to a degree that allows seedling success for Table Mountain pine and other pine species.
- Repeated low-intensity fires may contribute to the establishment of a stable mixed oak and Table Mountain pine community.

Table Mountain pine

Table Mountain pine, *Pinus pungens*, is a comparatively small pine species of an irregular round shape, ranging in size at maturity from 19 to 38 feet (6 to 12 meters). These typically occur as single specimens to small groves, and seldom are found in large forests like many other pines. They are unevenly distributed from southern Pennsylvania west to West Virginia, and south to Georgia. This pine prefers sandy or shaly ridge tops and south-facing slopes.

Research using dendrochronology shows that many current Table Mountain pine stands in the Appalachians are of uneven age, with trees ranging in age from 50 years to 150 years. This is probably due to open conditions maintained by low-intensity fires from 1850 to 1950. Since 1950, fire exclusion policies have encouraged the growth of dense thickets of mountain laurel (*Kalia latifolia L.*) and other understory species. It is believed that this has contributed to the low replacement levels of Table Mountain pine.



The range of Table Mountain pine extends from southern Pennsylvania to north Georgia.

Need for fire

Table Mountain pine exhibits several characteristics of species adapted to high intensity fire, including shade intolerance and serotinous cones. Thus, forestry scientists initially believed that high-intensity, crown fires were needed to completely kill competing hardwoods and create a germination bed for the pines. To encourage regeneration of Table Mountain pine, researchers and managers experimented with use of prescribed fires of varying intensity in the mountains of Georgia and South Carolina.

High and medium-high intensity fires (flames carried from crown to crown or flames reaching into the crown, respectively) killed most overstory trees and provided abundant sunlight for pine seedlings, as measured one year later. Sufficient seedling densities were found following all but some of the highest intensity fires. It was believed that regeneration wasn't successful in these areas because the absence of duff and high sun exposure resulted in excessive drying of the seedbed.

But these studies also suggested that medium-low and low-intensity fires (fires with occasional hot spots where flames reached lower limbs and flames of 3 to 6 feet, respectively) were not sufficient for regeneration as they did not kill enough overstory trees and left too much shade on the forest floor. Thus, the original recommendation was for the use of high intensity fires wherever practical to encourage effective regeneration.

Taking a second look

However, subsequent examination of these sites indicated that the initial observation that medium and low-intensity fires did not kill enough of the overstory to permit pine regeneration may not have been correct. Further, other historical work indicates that ridgetop pine communities in Georgia and South Carolina were created and maintained by multiple low-intensity fires rather than more infrequent higher-intensity fire.

View of a mountain ridge in north Georgia that shows a mixture of Table Mountain pine, pitch pine and chestnut oak.

A follow-up research project was designed to evaluate the longer term effect of these lower-intensity fires on pine regeneration. The principal investigator in this research was Thomas A. Waldrop of the Forest Service, Southern Research Station in Clemson, SC. The co-principal investigator was Mac A. Callaham, Jr. of the Forest Service, Southern Research Station, Athens, GA. This work was funded in part by a grant from the Joint Fire Science Program.

The study area

In the initial study, a total of 177 study plots, 0.05 acre in size, were established in five burn units. The areas studied are in the mountains in Chattahoochee National Forest in Georgia and Sumter National Forest in South Carolina. Burns were conducted in the winters of 1998 through 2004. Each burn unit was a minimum of 500 acres in size. The study plots were established in portions of the burn unit occupied by Table Mountain pines, predominantly on the ridges and south-facing slopes.

Fire behavior ranged from subcanopy ground fires to crown fires reaching above the stand canopy. Fire intensity was described for each plot using categories ranging from low to medium-low, medium high, and high. Observed fire behavior for each category was described as subcanopy ground fires (low), subcanopy ground fires with hot spots where jackpot fuels occurred (medium-low), flames reaching into overstory tree crowns (medium-high), and flames equal to or exceeding tree height (high).

Pre-burn and first-year post-burn measurements included overstory tree diameter at breast height (dbh), species and mortality; hardwood abundance; and species and size of pine regeneration. Data was collected up to 10 and 11 years post fire. At each of the 28 subplots, 6.5 by 6.5 feet in size, regeneration was measured. Hardwood sprouts and seedlings were counted and recorded by species in one randomly selected quadrant of each of the 28 subplots.

Initial observations

According to Waldrop, regeneration in nearly all cases is achieved with cone-dropped seed, not through survival of small seedlings. “There is essentially no advance Table Mountain pine regeneration. Everything is from seed released after the fire.”

The observations one and two years after the fires indicate that the higher intensity fires promoted more abundant growth of Table Mountain pine seedlings than the lower intensity fires. On a limited number of sites, there was no immediate evidence of pine regeneration. Researchers speculated that this was due to lack of a nearby seed source, reduced mycorrhizal abundance, and/or drier soil conditions due to less shading. Low-intensity burn plots had 1,278 pine seedlings per acre the first year but only 100 per acre the second year. This result suggested that overstory shading was preventing survival of seedlings.

A concern for pine survival is competition from hardwood and shrub sprouts. During the year immediately following the fire, there were large numbers of sprouts from all hardwood and shrub species and they tended to overtop the pines. Common were mountain laurel, blackgum, oak and sassafras.

High-intensity is a challenge

Based on these results, it appeared that to successfully nurture a healthy growth of new pines, a high-intensity fire is necessary. However to achieve this level of prescribed fire without smoke or safety risks is difficult and prescription windows are often very narrow. To do so is particularly challenging in areas where there is thick and explosively flammable undercanopy such as mountain laurel.

Waldrop feels these are of special concern because of the difficulty of managing prescribed fires in this very flammable type of brush. “Some fire managers have been able to run a very low-intensity fire underneath mountain laurel on dry days without a lot of wind. However, in my opinion the number of these days is very limited.”

The plot thickens

The study indicated that during years beyond the second year after the fire, there was an apparently delayed effect of the low-intensity fires on hardwoods, as overstory trees continued to die. As a result, pine regeneration numbers in these plots increased to over 3,700 per acre in year six. A total of 859 pines per acre survived by the 10- to 11-year interval.

Thus, even in the lowest intensity fire areas, researchers concluded that even though pine regeneration numbers varied greatly from year to year, the overall density of pines was satisfactory for all fire intensity categories. It is believed that it is not necessary to use high-intensity fire to have successful pine regeneration.

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Waldrop notes that the lower-intensity fires studied were still fairly hot compared to the entire range of possible intensities. “They were simply the lowest in our study of stand-replacement fires." He adds, "Those types of fires are very practical. A very low-intensity fire with six-inch flames would be impractical, but not impossible."

The beginning of a new stand. Photo shows a tiny seedling of Table Mountain pine (center) approximately two months after a low-intensity fire.

The research did not demonstrate that fire intensity was the controlling factor for Table Mountain pine regeneration. Researchers believe an important factor may be the presence of cones on the trees in the fire area, and the degree of openness of those cones. This suggests that it may be appropriate to do a cone survey before planning a prescribed fire to help estimate the potential value of the fire for cone-based regeneration.

Open serotinous cones of Table Mountain pine two days after burning. These show the promise of successful regeneration.

The hardwood story

Initially, density of shrub and hardwood sprouts was greatest in areas where the fire intensity had been highest. However, it is believed that this difference was due to higher densities of these woody species before the fires, hence the higher fire intensities.

The greater number of hardwood and shrub sprouts in areas of high- and medium-high intensity continued for the first six years, and in all areas the hardwood sprouts overtopped the pines at six years. At this time, the hardwoods were approximately 7 feet tall while Table Mountain pines were 3 to 4 feet tall, and pitch pines were 2 to 3 feet tall.

Research has shown the value of this type of low-intensity burn for Table Mountain pine regeneration. This photo shows a site three days after the fire.

However, the Table Mountain pines grew more quickly between years 6 and 11, and by the final year of the project, they had overtopped hardwoods and shrubs in plots burned at all intensities except the medium-high category. Pines and hardwoods were both generally taller when growing in plots burned at the higher intensity categories, suggesting an initial shading effect from residual overstory trees left in plots burned at lower intensity. However, in nearly all cases, the hardwood and shrub sprouts were taller than the pine sprouts until about year six. After that, pine growth rates accelerated and overtopped the hardwoods and shrubs by years 10 and 11.

Other pine species

In addition to the Table Mountain pine, other pine species are included in the regeneration. Waldrop says, "I have one stand that contains six species of pine (Table Mountain, pitch, shortleaf, Virginia, white, and loblolly) and all compete well. What we have seen with these stand replacement fires is Table Mountain pine the first year after the fire from seeds from the serotinous cones in the burn unit. The following years saw increasing numbers of pitch pine from seed coming from areas adjacent to the burn."

Waldrop indicates that the pitch pine and Table Mountain pine are usually dominant. "Our oldest stand has an even mixture of Table Mountain and pitch pine regeneration." He explains that pitch pines drop seed every autumn and those are often consumed by winter fire. Table Mountain pine seed drops within days after the fire or at any time during the next year."

Revised successional model

Field studies indicated that in the pre-European period of frequent low-intensity fires, there was a stable baseline population of Table Mountain pine mixed with other pine and hardwood species. In the period 1850–1950 there was a marked increase in Table Mountain pine abundance stimulated by logging, fire and disease. After 1950 there has been a significant decline in replacement Table Mountain pine, apparently a result of fire exclusion. None of the sites has had a successful regeneration in several decades before the experimental fires.

Prior to 1950, most fires were widespread, of moderate to low-intensity, and occurred during the dormant season. This suggests they were caused by humans and would typically spread upslope from their point of origin. In Georgia and Tennessee, some small fires occurred during the growing season, which suggests they were caused by lightning. However, this type of fire is rare in this region.

Some have argued that Table Mountain pine communities would convert to stable oak forests in the absence of fire. In fact, this research suggests that oaks also stopped regenerating in the absence of fire. Stable mixed oak and Table Mountain pine forest was the norm when there were periodic low-intensity fires. In the absence of fire, both oaks and pines declined and were succeeded by shrubby thickets of mostly mountain laurel.

Achieving open woodland

In some case, management objectives may call for restoration of open woodland. This study indicates that a single fire can begin the process of open woodland, but because of the sprouting characteristics of hardwood and shrubs, a single fire may not be sufficient. The historic record suggests that this woodland type was the result of repeated low-intensity fires. To recreate it, Waldrop says that frequent low-intensity fires are probably necessary. "In an ideal world, I would like to see annual burning for several years until fuel loading becomes too low to burn that frequently. In the real world, a fire every three years seems to be a good balance between biological needs and practicality. This would gradually reduce the forest floor and open the stand." Waldrop indicates he knows of only one case where this has been attempted. "Others are in the planning stage."

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Additional work needed

According to the researchers, more work is needed in development of practical prescribed burning and other tools to allow management for Table Mountain pines in the Southern Appalachians. They note that in some young regenerated stands, pines are dense, numbering 1,600 stems per acre. However, the hardwood stems are extremely thick—as many as 8,000 per acre. Work is needed to determine if prescribed burning or mechanical release can help ensure the success of the preferred pine community.

Also needed is more information on the potential success of repeated low-intensity burning to achieve the desired release of pines while controlling the regrowth of hardwoods and shrubby understory species. More needs to be learned about the impacts of low-intensity burning on competitors such as red maple, yellow-poplar, and invasive plants.

Management Implications

- To develop a stable mixed oak and Table Mountain pine community, repeated low-intensity fires are probably the most valuable tool.
- Suppression of overstory hardwoods and shrub species can be achieved with relatively low-intensity fires. Mortality of overstory trees may take several years to complete.
- Prescribed higher-intensity fires can stimulate faster regeneration, but because of safety and smoke management considerations and narrow prescription windows, these types of fires may be difficult to schedule.
- Contrary to earlier beliefs, shrubby understory species rather than mature hardwoods are often the deterrent to regeneration of Table Mountain pine. These can often be controlled by prescribed low- and moderate-intensity fires.
- Other pine species, especially pitch pine, will eventually inhabit the same regeneration site along with Table Mountain pine.

Further Information: Publications and Web Resources

Brose, Patrick H. and Thomas A. Waldrop. 2006. Fire and the origin of Table Mountain pine—Pitch pine communities in the Southern Appalachian Mountains. USA. *Canadian Journal of Forestry Research*.

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Scientist Profile

Thomas A. Waldrop is Research Forester and Team Leader for Fire Science in the Southern Research Station's Center for Forest Disturbance Science in Clemson, SC. His work emphasizes fire ecology in the Piedmont and Southern Appalachian Mountains with research on firing techniques for stand replacement of Table Mountain pine, fire history, fuel loading characteristics of the Southern Appalachians, and impacts of stand replacement fire on various components of mountain ecosystems. He is currently developing the Consortium of Appalachian Fire Managers and Scientists to enhance science delivery for fire professionals in the Central and Southern Appalachian region.

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